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Dynamics and Modelling of Ocean Waves. G. J. Komen et al. 1994. 532 pp. $59.95. Hardbound. Cambridge University Press. ISBN 0-521-47047-1.

For nearly a decade, between 1984 and 1992, a group of international wind wave aficionados assembled at selected locations in Europe and North America for a yearly springtime meeting. One of the objectives of these meetings was to promote the continuous development and application of a third generation wave model, the so-called WAM model. These meetings were thus widely known as the WAM meetings, and the active participants of the meetings became members of the WAM group. This book, as the final report of the WAM group, represents a culminating milestone of the WAM meetings. As an occasional visitor of the WAM meetings, I have been looking forward to the publication of this book.

This book is indeed an extensive incorporation of most of the pertinent and state-of-the-art knowledge and information on wind waves and wave modeling.

The authors, led by Gerbrand Komen along with 35 expert contributors from the WAM group, have to a large extent achieved their intended goals to produce a book that "should reflect the multi-disciplinary nature of WAM (basic physics, modeling, applications, and satellites) and should be suitable as an introduction to the field." This book is indeed an extensive incorporation of most of the pertinent and state-of-the-art knowledge and information on wind waves and wave modeling. The massive contents of this book have for many years been available only in widely scattered journals and reports. This book will be of utmost interest to those who are interested in the study of wind waves and wave forecasting, including meteorologists and oceanographers, as well as coastal and marine engineers.

The book has seven chapters. The first six are primary chapters prepared correspondingly by each of the six leading authors. The seventh chapter is a short account of collective wisdom on summary and outlook. While the book is entitled *Dynamics and Modeling of Ocean Waves,* the thrust is clearly on modeling. At the core of the wave modeling efforts lies the concept of the "action balance equation" that governs the physics of the evolution of the surface wave field by equating the rate of change of the action energy density spectrum to a source function. The organiza-

tion of this book conveniently revolves on the essential aspects of the action balance equation. Chapter I presents linear and nonlinear approaches to random wave processes leading to a systematic derivation of the theoretical action balance equation. Chapter II, being the longest chapter of the book, brings together an assortment of 10 different theoretical and observational wave dynamics studies that provide the basis for the rational formulation of the source function terms. The next two chapters, which represent the principal contributions of this book, present the detailed substance of the WAM model. Chapter III describes the formulation of numerical solutions of the action balance equation, the optimal parameterization of the source terms, and the model implementation. It can also be regarded as an in-depth users' guide for the WAM model software. Chapter IV illustrates the comprehensive and compelling applications to wave hindcasting and forecasting operations. Of particular interest to the meteorologist are discussions of the characteristics and sensitivities of surface wind fields for various model applications. And finally, chapters V and VI introduce advanced topics of using satellite technology and wave data assimilation to further refine the practice of action balance equation modeling. Chapter VI is certainly a gracious starting point for learning data assimilation techniques.

To elucidate the significance of third generation WAM modeling, perhaps some background of the historical development of wave modeling is in order. The evolution of the modern practice of ocean wave modeling has customarily been traced back to the early 1940s when Sverdrup and Munk (1947) devised the technique of forecasting waves for the Allied forces during the Normandy landing. The adaptation of numerical wave modeling, however, became widely explored only in the 1960s following the theoretical developments of Phillips, Miles, and Hasselmann. Regional wave models were developed at many local areas of the World Ocean. Based on various formulations of source functions, the wave models developed in the early years can be classified as either first generation models, which used only linear terms for the source function, or second generation models, which attempted to include the effect of nonlinear energy transfers with simple parameterizations. In an early book entitled *Ocean Wave Modeling* that was published in 1985, the SWAMP (Sea Wave Modeling Project) group compared the operational results of 10 different first and second generation models applied under identical predescribed hypothetical conditions. The results showed striking differences among the predictions of these different models. While the differences were not unexpected, they nevertheless signified the exigency of a new generation of modeling with better representations of the nonlinear couplings of wind wave processes. Conceivably, the SWAMP group is a forerunner of the WAM group. The intense efforts of developing a third generation model started shortly before the publication of the SWAMP book. Many of the key WAM group members were also key players in the SWAMP group.

After a decade of profound developments, the third generation WAM model has principally overcome the recognized shortcomings of the earlier first and second generation wave models. Branded as "one of the best tested wave models in the world," the latest WAM model, as presented in this book, clearly demonstrates its strength and versatility as an effective wave forecasting model operational for both global and regional ocean applications. Beyond the wave modeling, as the title of the book suggests, this book also contains a whole range of studies on ocean wave dynamics. Indeed, while reading this book, it is difficult not to be impressed with the breadth and depth of the coverage of the subject matters. As a synthesis of many years of international collaborations on model development and wave dynamics studies, almost every section tends to be reporting on the findings of ongoing research programs. While this is not a textbook, this book is destined to be a helpful reference that every practitioner and student will want to consult frequently. For an aficionado seeking research inspiration, this book unquestionably stocks a wealthy collection of exciting research topics on wave dynamics and modeling.

Amid all the enthusiasm that I have for this book, I would like to register two minor complaints. First, I find there is no clear instruction as to how an interested party can acquire the latest WAM model for testing and applications. My advice right now would be to write directly to the leading author, Gerbrand Komen. In addition, I understand the code for the WAM model is basically written for supercomputers, which severely limits its use to only a few fortunate people having supercomputer connections. Many of the applications presented in this book were conducted at the European Centre for Medium-Range Weather Forecasts. In an era of increasingly wide-ranging use of personal workstations and personal computers, I wonder if the WAM software can be converted to workstation and PC versions for broader applications.

Next, a comment on the style of the writing. At times the authors tend to be somewhat sanctimonious and unsympathetic to alternate approaches. For instance, I can fully understand the detailed elucidation of the work of Hasselmann and Hasselmann (1985) in estimating the nonlinear energy transfer, which is central to the success of the WAM model. I was mildly surprised, however, that earlier key developments of

Fox (1976), Webb (1978), and Dungey and Hui (1979) were not even mentioned.

In summary, this book shows us an exciting exposition of the state of the art of wave modeling and wave dynamics as of the early 1990s. Allow me to use a cliché here: we have come a long way. Yes, indeed, from Sverdrup and Munk through SWAMP and on to WAM. We are now able to make global forecasts and take advantage of available satellite technology. However, the authors have eloquently cautioned that "Despite the progress, we still are not able to make wave predictions that always fall within the error bands of the observations." The authors are not optimistic about better physics and further refinements. I disagree. I feel that we are still at the beginning of our task of exploration of ocean wave dynamics. New instruments and advanced data analyses will be developed. The next decades and next century will certainly bring further excitement to the field, perhaps a fourth generation model. Why not? We are not in a position for complacency.

In the meantime, I strongly recommend this book to all past, present, and future aficionados. I commend the Cambridge University Press for keeping this book at a relatively reasonable price.—*Paul C. Liu.*

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Editor's note: According to Paul Liu, copies of the workstation version of the WAM model are now available from Gerbrand Komen, author of Dynamics and Modelling of Ocean Waves.